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Lead-Glazed Ceramics As Major Determinants of Blood Lead Levels in Mexican Women

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The aim of this study was to determine the main contributors to blood lead levels in a population of women from middle to low socioeconomic status in the southwestern part of Mexico City. Within this area, the authors selected a random sample of 200 women. Age ranged from 21 to 57 years, with a mean of 36 years. Among 99 women who agreed to participate in this study, blood lead levels ranged from 1 to 52 μg/dL, with a mean of 10.6 μg/dL. Five percent of the women had a blood lead level over 25 μg/dL and 22% over 15 μg/dL. There was no significant trend in blood levels according to age. The main determinants of blood lead levels were higher socioeconomic status (presence of telephone in the house, t-test, $p = 0.01$) and using lead-glazed ceramics (LGC) to prepare food (t-test, $p < 0.005$). There was a significant increasing trend in blood lead levels with increasing frequency of consumption of food prepared in LGC (test for trend, $p = 0.0008$). Among the dishes prepared in LGC, the main determinant was the consumption of stew. Time spent outdoors and consumption of tap water and of canned food were not important determinants of blood lead levels. The population attributable risk of high blood level (< 15 μg/dL) due to the use of LGC was 58%. These findings demonstrate the major role of traditional pottery as a contributor to blood lead levels in this population and emphasize the need for interventions to produce lead-free pottery.

Introduction

Different environmental media are responsible for the lead burden in individuals: inhaled air, dust, drinking water, and foods. The main ways of absorption are through the respiratory tract and the digestive system. In adults, pulmonary absorption corresponds approximately to 30 to 50% of the quantity inhaled (*1*). The rate of gastrointestinal lead absorption from a typical diet is 10 to 15% of the ingested quantity (*2*). However, such absorption may vary. When lead is consumed in aqueous solution with food, intake from the gut may be as high as 80%, even in persons with good dietary status.

Many countries are facing an epidemic of low-level lead poisoning. In Mexico City there are sparse data on the blood lead levels in the population (*3–5*). Studies carried out by the World Health Organization in 1982 and 1986 among school teachers living in 10 cities of the world showed that the highest levels were observed in Mexico City (*3,4*). However, in these studies there was no information of sources of lead in the different populations, and school teachers are far from being representative of the Mexican population. More recently, a study conducted among members of the Social Security System (ISSSTE) showed that men experienced a higher blood lead level than women and that the main predictors of blood lead levels were the area of residency, time spent in traffic, consumption of food cooked in low-temperature pottery, and the consumption of canned chili (*5*). In this study we investigate the determinants of blood lead levels in a random sample of housewives aged 21 to 57 years living in the southern part of Mexico City.

Methods

As part of a longitudinal study to validate a dietary questionnaire, we obtained information on potential sources of lead exposure in a population of women from medium to low socioeconomic status in the southern part of Mexico City.

Study Population

We randomly selected an age-stratified sample of 527 women residing in Tlalpan, the southern district of Mexico City. Among

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them, 211 women (41%) agreed to participate in the study, and 107 women provided blood samples. The main reason for nonparticipation was impossibility of complying with the complete protocol of the validation study, which involved the donation of two blood samples of 20 mL, the recording of food intake during 4 days, four times a year, and the completion of a food frequency questionnaire before and after diet recording.

Collection of Information

Women participating in the study were visited at home by specially trained interviewers. During the visit, a general purpose and lead exposure questionnaire was applied. This questionnarie included demographic and socioeconomic items as well as specific questions about lead exposure such as *a*) the use of low-temperature pottery to prepare and serve foods; *b*) the frequency of consumption of such foods; *c*) the consumption of canned food; *d*) smoking habits; *e*) time spent in traffic per day; *f*) time spent outdoors per day (walking or exercising); *g*) profession of the spouse (potential work exposure to lead) and laundry of work clothes of the spouse by the wife; and *h*) presence of car battery repair factory near the household.

Questions on the use of low-temperature pottery were illustrated by photographs because the lead content of such items varies according to the type used. This questionnaire was applied to all the women with a 3-week period, and blood and tap water samples were obtained at the same time.

Blood and Water Lead Measurement

To eliminate external lead contamination, all glassware and plastic materials, including polypropylene tubes used to collect blood samples, were immersed for several hours in 3% nitric acid and then thoroughly rinsed with deionized water. Blood samples were available for lead measurement in 99 women and kept in heparinized, lead-free tubes at 4°C until analysis. To determine blood lead levels, heparinized blood was vortex mixed, and 100 μg of blood was transferred to 2.9 mL of lead-free metexchange reagent in a polyethylene cuvette. The cuvette content was mixed gently, then placed on the cell of an anodic voltameter (model 3010 trace metals analyzer ESA) and stirred for 5 sec before pressing the analysis button (*6*). Calibration was performed by using low and high level lead standards supplied by the manufacturer, Environmental Science Associates (ESA). Additional quality control was performed by measuring bovine blood samples with known lead concentrations (kindly provided by the Centers for Disease Control, Atlanta) and by comparing our results with those obtained by a certified laboratory. Ten percent (n = 10) of blood samples were also measured by the Centers for Disease Control. The means obtained by both laboratories were the same, and the correlation coefficient was 0.90. Water lead was analyzed as recommended by Hunt and Winnard (*7*) using a Perkin-Elmer 360 atomic absorption spectrophotometer with an HGA-2200 graphite furnace. Calibration curves were built using a 10,000 mg/L aqueous standard properly diluted with deionized water.

Study participants were instructed to collect the first run from the tap in order to sample water that was left standing over night. Water was collected in lead-free containers that were provided to study participants.

Statistical Analysis

Since the distribution of blood lead levels was skewed, natural log-transformed values for this variable were used for all analyses. The statistical significance of the mean difference between the blood lead levels according to specific characteristics of the population was assessed using F-tests. Univariate linear regression analysis was used to determine significant predictors of blood lead levels. Multivariate regression analysis was used to examine the independent effect of specific variables with simultaneous adjustment for other predictors of blood lead levels. All statistical analyses were performed using SAS software (*8*).

Results

In this population of 99 women, age ranged from 21 to 57 years, with a mean of 36 years. Blood lead levels ranged from 1 to 52 μg/dL, with a mean of 10.6 μg/dL. Five percent of the women had a blood lead level over 25 μg/dL and 22% over 15 μg/dL.

There was no significant trend in blood levels according to age. Among the socioeconomic variables commonly used in Mexico to discriminate between subjects, the only significant variable was the presence of a telephone within the house. The mean blood level in women with a phone was 7.9 μg/dL versus a mean of 11.4 μg/dL among those women without a phone in the house (Table 1). We did not observe any difference in the average blood lead levels among women who smoke in comparison with those who did not smoke.

Cooking and eating habits were important determinants of blood lead levels. Women who prepared food in lead-glazed ceramics were more likely to have a higher blood lead level as compared with women who never used lead-glazed ceramics (LGC) (Fig. 1). There was a significant increasing trend in blood lead levels with increasing frequency of consumption of food prepared in LGC (Fig. 2). Women who ate food in LGC were also more likely to have higher blood lead levels than women who never eat in such pottery. Among the dishes prepared in lead-glazed pottery, the main determinant of blood lead levels was the consumption of stew (Fig. 1).

Table 1. Blood lead levels (μg/dL) according to socioeconomic variables among women aged 21 to 57, Tlalpan, Mexico City, 1990.

Items	n	Mean	SE	Range	F-test
Number of subjects living in house					
1–4	35	11.2	7.3	1–29	NS[a]
5–6	41	10.3	8.8	1–52	
7+	23	10.2	8.1	1–33	
Number of rooms in house					
1	36	12.4	9.9	2.5–52	NS
2	27	10.3	6.2	1–24	
3+	36	9.0	7.1	1–33	
Water within house					
Yes	54	10.7	7.5	1–33	NS
No	45	10.6	8.8	1–52	
Type of floor in house					
Cement	89	10.4	7.9	1–52	NS
Wood	10	12.4	10.0	2–32	
Refrigerator					
Yes	72	11.9	7.4	3–33	NS
No	27	10.1	8.3	1–52	
Phone in house					
Yes	23	7.9	5.7	1–21	0.01
No	76	11.4	8.5	1–52	

[a]NS, nonsignificant.

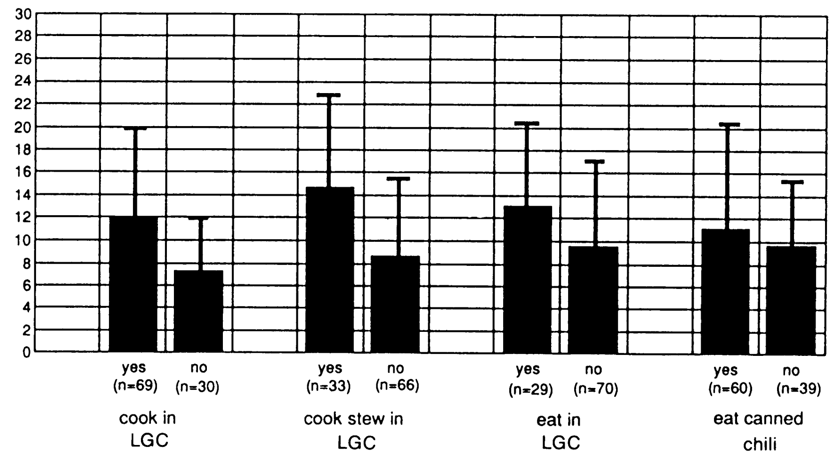

FIGURE 1. Blood lead levels according to eating habits among women aged 21 to 57 years, Tlalpan, Mexico, 1990. LGC, lead-glazed ceramics.

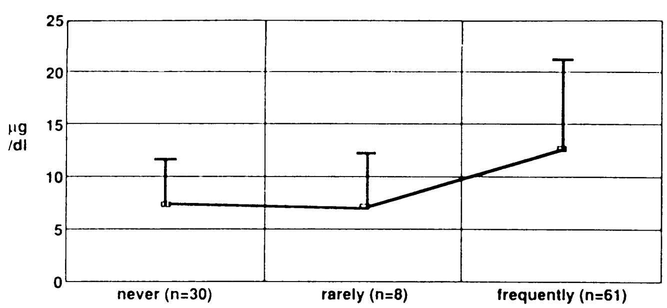

FIGURE 2. Blood lead level according to frequency of consumption of food prepared in lead-glazed pottery among women aged 21 to 57 years, Tlalpan, Mexico, 1990. Test for trend, $p = 0.0008$.

Table 2. Multivariate analysis of covariance[a] including determinants of blood lead levels among women aged 21 to 57 years, Tlalpan, Mexico City, 1990.

Variables	F	p
Cook food in LGC[b]	1.01	0.32
Cook stew in LGC	7.46	0.007
Frequency of consumption of food cooked in LGC	2.13	0.15
Eat food from LGC	0.46	0.5
Phone in house	6.64	0.012

[a] R^2=25%.
[b] LGC, lead-glazed ceramics.

The consumption of canned food or tap water were not important determinants of blood lead levels. Ninety-four percent of the women reported eating canned food, and their blood level was not different from that observed for those women who did not eat canned food. Women who ate canned chili had a slightly higher blood lead level then women who did not (11.2 µg/dL versus 9.7 µg/dL); however, this difference was not statistically significant.

None of the variables regarding time spent outdoors in traffic or exercising outdoors were important determinants of blood lead levels. Similarly, women whose spouse worked in a place with potential exposure to lead and who washed their spouse's workclothes at home did not have higher blood levels than their counterpart; however, the small number of subjects working in an overexposed environment precludes any analysis regarding this variable.

When all significant determinants of blood lead levels were entered in a multivariate model, the variables that remained significant were the consumption of stew prepared in LGC and the presence of a phone within the house. Our model explained 25% of the variability of blood lead levels (Table 2).

Discussion

In this population of women living in the southern part of Mexico City, the main determinants of blood lead levels were the use of LGC to prepare food and being of lower socioeconomic status (as defined by not having a phone in the house). Our results are representative of a well-defined population, and inference of the results is justified. Although some women did not agree to provide blood samples, their socio-demographic characteristics and the use of LGC did not differ from that of women who provided blood samples.

Considering a high blood lead level to be over 15 µg/dL, we calculated that the population attributable risk of high blood lead level due to the use of LGC to prepare food was 58%. This emphasizes the public health importance of investigating lead-glazed pottery in Mexico City and highlights the benefit expected by the regulation of the lead content in pottery production.

Our results are in agreement with findings reported by Lara-Flores et al. (*5*) and Rothenberg et al. (*9*). These authors reported that use of LGC was a major determinant of blood lead levels. The positive trend observed between blood lead levels and frequency of consumption of food prepared in LGC supports that such association is not spurious. In our study, in order to minimize misclassification, we used pictures to better classify subjects using LGC. Lead is present mainly in the glaze and the painting used to cover the earthenware dishes, and some of these dishes may not contain lead depending on their characteristics. The preparation of dishes containing acid foods such as tomatoes and chili are more likely to remove lead from the pottery, especially when cooked for several hours, which explains the strong association observed for "traditional stew" as a deteminant of blood lead level.

In contrast with the findings of Lara et al. (*5*), the consumption of canned foods and, more specifically, canned chili, was not a significant predictor of blood lead levels. In our population, 67% of the women declared eating canned chili. However, the frequency of consumption was low, which may explain the lack of significance of this variable in our analysis. In addition, during the last 3 years, the largest canned food companies have changed their processing, excluding the use of lead (E. Palazuelos, personal communication). This change may have produced misclassification in this variable.

Lead levels in drinking water could be high when soft/acidic water flows through lead pipes. In Mexico, houses are connected to a street collector through a lead-pipe connection; however, in our study, tap water drinking had no effect on blood lead. This is not surprising because all water measurements were below the World Health Organization Guideline (2 ppm/L), with a mean of 0.1 ppm/L. In addition, water in Mexico City is rather "hard" (pH > 7), therefore, heavy metals such as lead would tend to precipitate.

Tobacco smoking has been shown to increase lead exposure, probably because of lead-containing pesticides. Because these pesticides are no longer in use, the contribution of tobacco is relatively small. A recent study determined that concentrations in tobacco were low (*10*). Our study confirms the major role of the use of traditional pottery as a determinant of blood lead levels in Mexico City. This toxic potentiality of lead-glazed ceramics has been known for several decades (*11–13*); however, regulation has not been enforced. This finding is important because regulation of the production of this traditional lead-glazed pottery could have a major impact on the blood lead levels of women of reproductive age and therefore on the potential alteration of the neuropsychological development of their newborns.

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